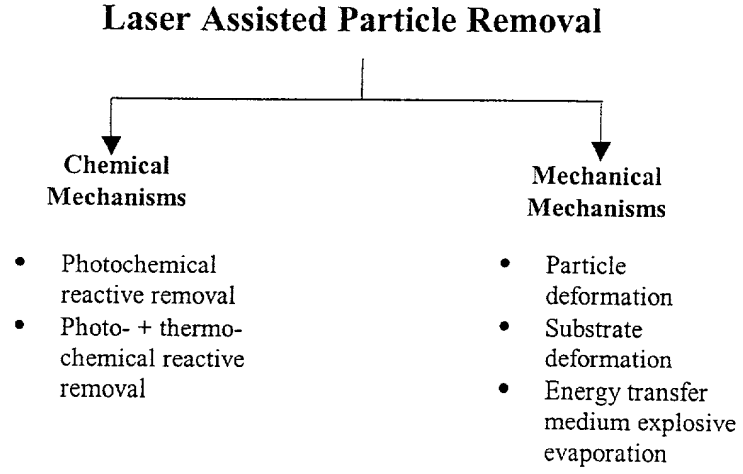

Laser Assisted Particle Removal
Chemical Mechanisms
Photochemical reactive removal
Photo- + thermo-chemical reactive removal
Mechanical Mechanisms
Particle deformation
Substrate deformation
Energy transfer medium explosive evaporation

Fig. 1

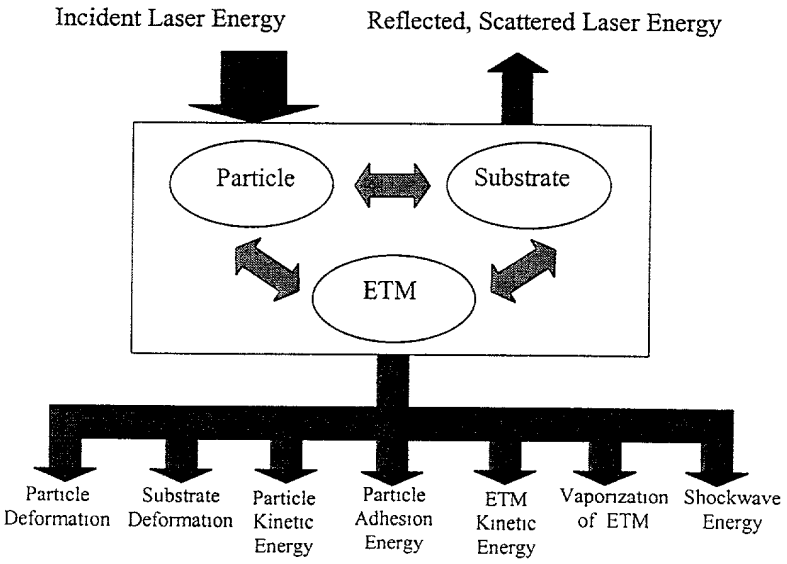

Incident Laser Energy
Reflected, Scattered Laser Energy
Particle
Substrate
ETM
Particle Deformation
Substrate Deformation
Particle Kinetic Energy
Particle Adhesion Energy
ETM Kinetic Energy
Vaporization of ETM
Shockwave Energy

Fig. 2

Absorption Medium	Particle	ETM	Substrate with ETM	Substrate without ETM
Removal Mechanism	Rapid thermal expansion of particle	Explosive evaporation of ETM	Microbubble formation at liquid/solid interface	Rapid thermal expansion of the substrate
wavelength	λ<<Particle Diameter	λ>>Particle Diameter	λ>Particle Diameter	λ>>Particle Diameter or λ<Particle Diameter if $\alpha_{particle}$ is low
Energy Absorption	$\alpha_{particle} >> \alpha_{substrate}$	High α_{ETM}	High $\alpha_{substrate}$	High $\alpha_{substrate}$
Substrate Damage	-Melting/Ablation of particle	Shockwave, substrate absorption	-Melting/Ablation of particle or substrate -Shockwave in ETM	Melting/Ablation of particle or substrate
Particle Removal Threshold	Φ_{th}=0.01-0.08 J/cm^2 I_{th}=1-11 MW/cm^2 D=20 μm	Φ_{th}=0.65-2.2 J/cm^2 I_{th}=3-11 MW/cm^2	Φ_{th}=0.02-0.3 J/cm^2 I_{th}=2-600 MW/cm^2 τ=0.03-20 ns	Φ_{th}=0.02-0.3 J/cm^2 I_{th}=1-30 MW/cm^2 τ=7-30 ns

Fig. 3

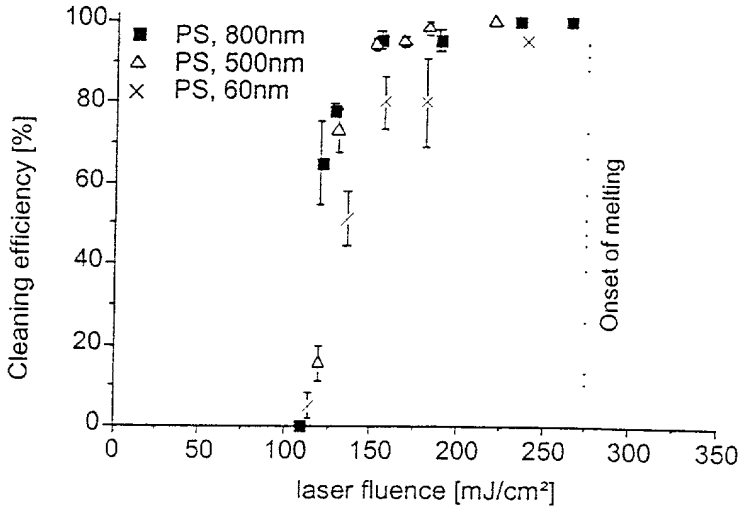


Fig. 4

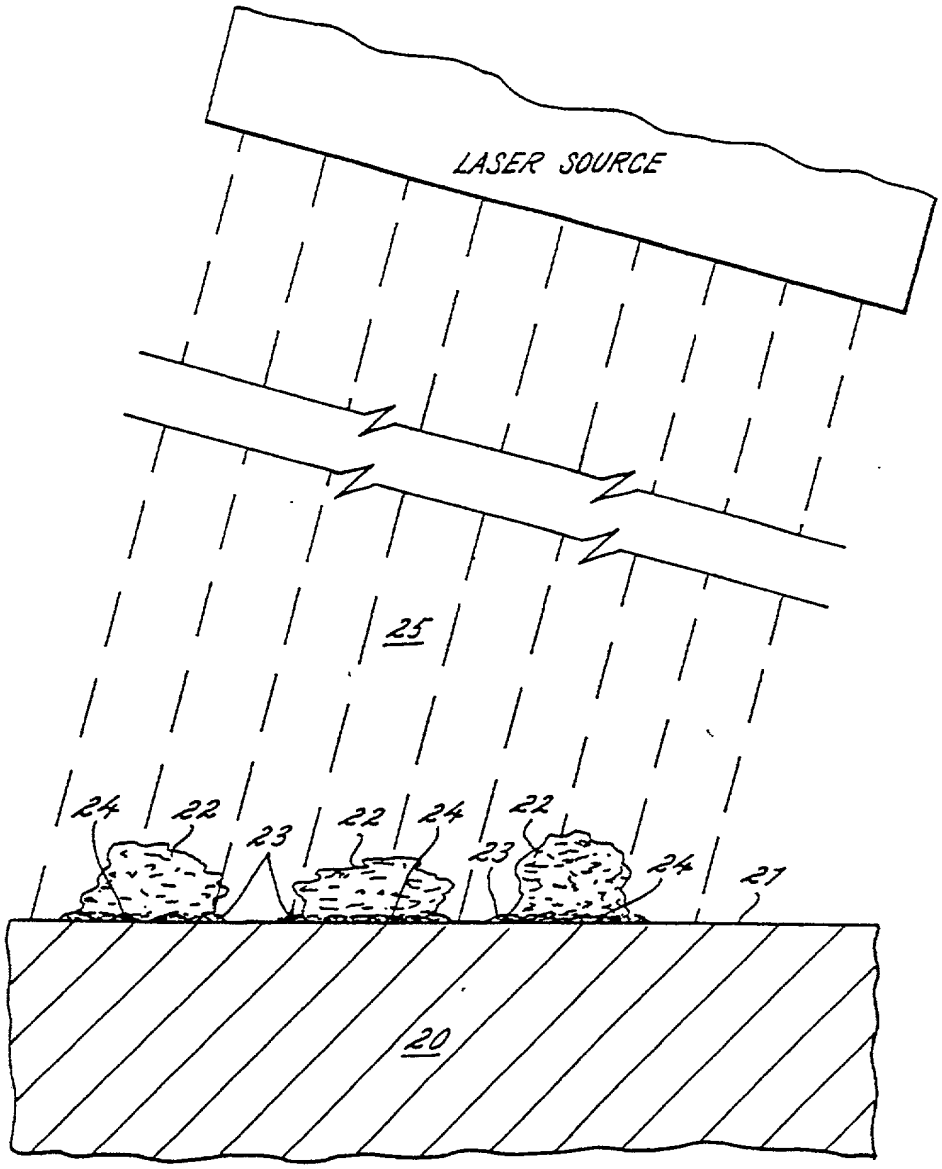


FIG. 5

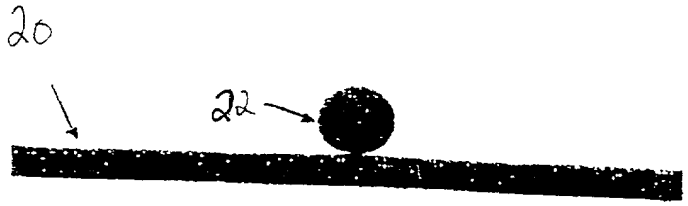


Fig. 6A

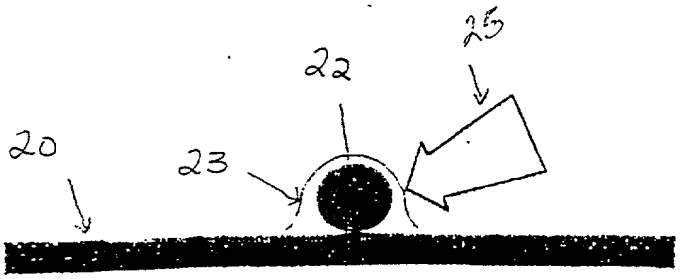


Fig. 6B

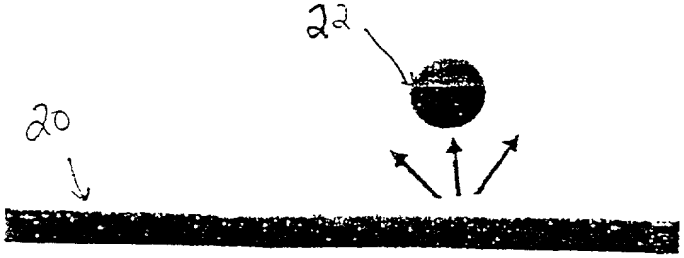


Fig. 6C

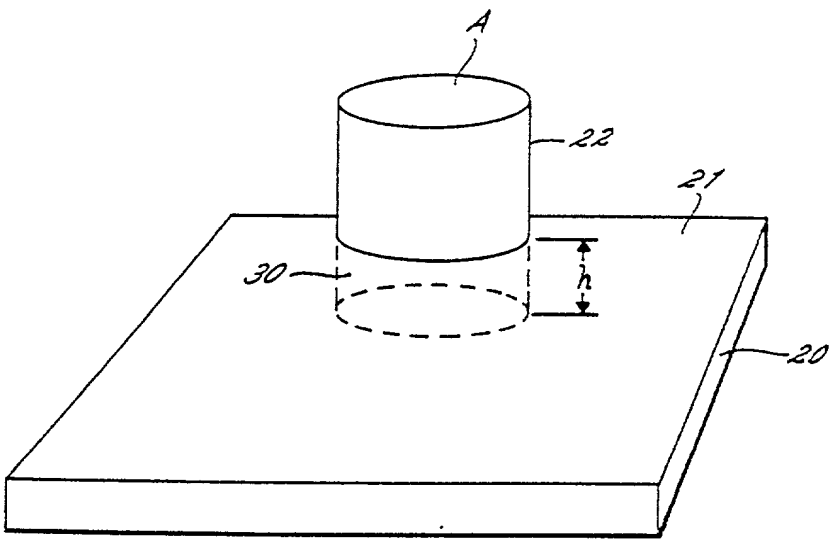


FIG. 7

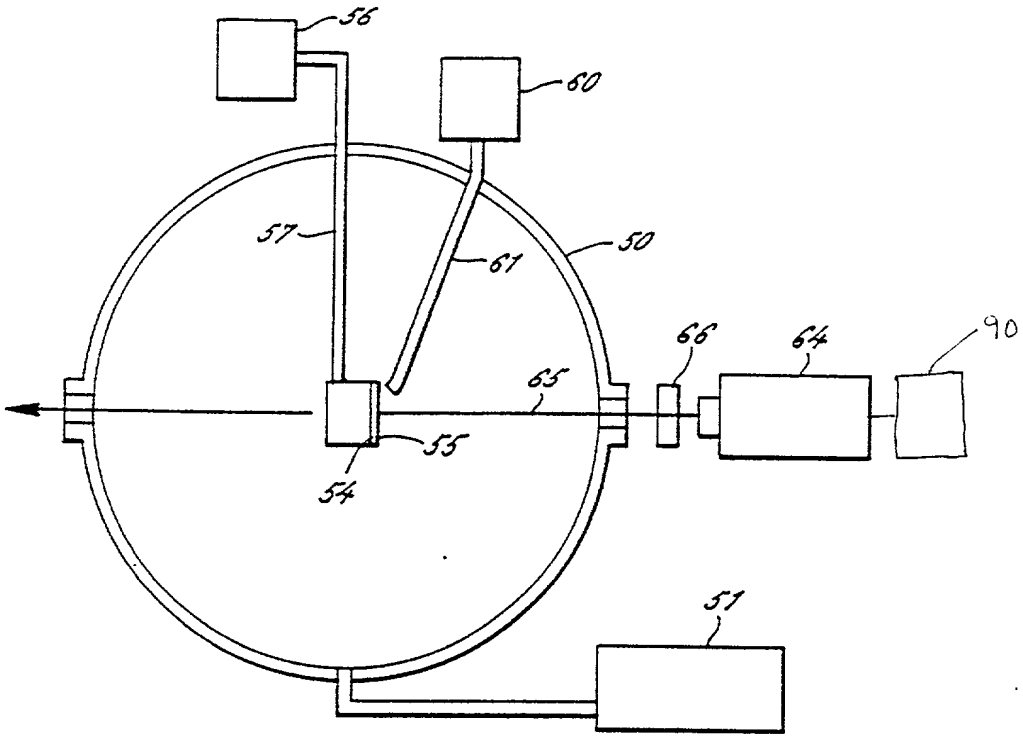


FIG. 8

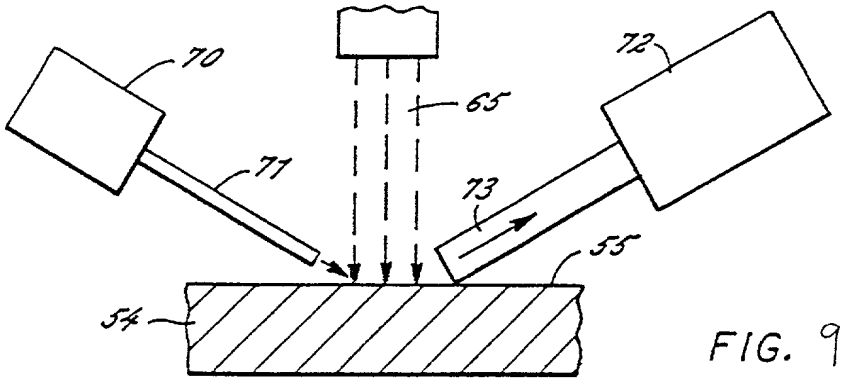
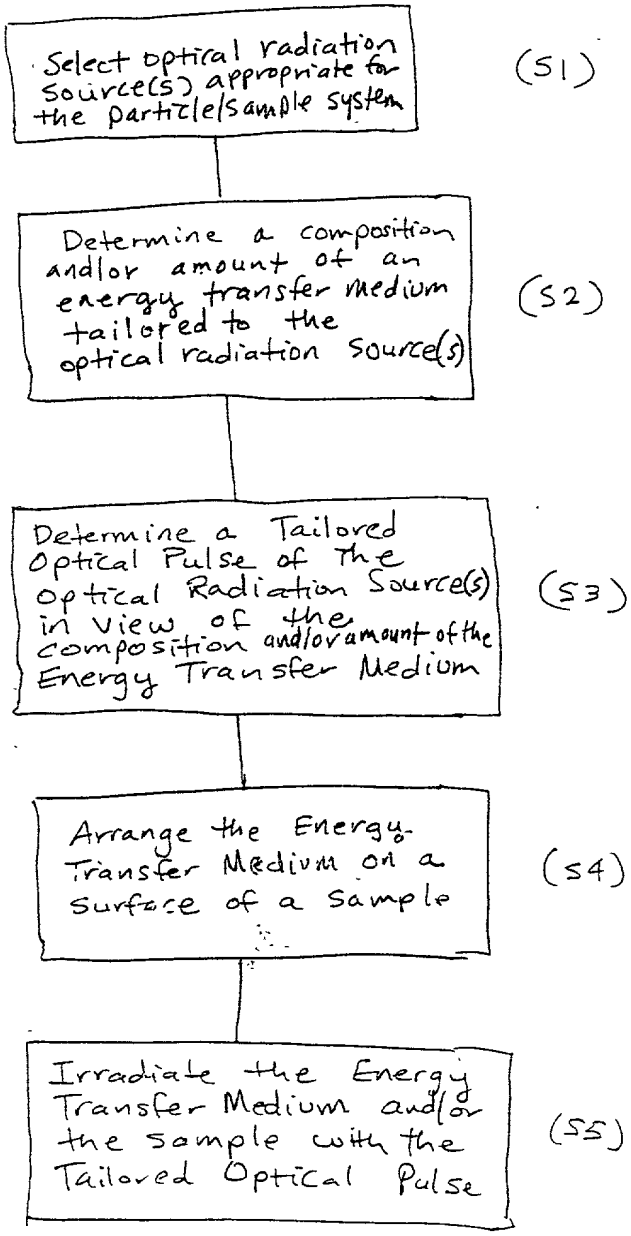


FIG. 9

Figure 10


Select optical radiation source(s) appropriate for the particle/sample system
(S1)
Determine a composition and/or amount of an energy transfer medium tailored to the optical radiation source(s)
(S2)
Determine a Tailored Optical Pulse of the Optical Radiation Source(s) in View of the composition and/or amount of the Energy Transfer Medium
(S3)
Arrange the Energy-Transfer Medium on a Surface of a Sample
(S4)
Irradiate the Energy Transfer Medium and/or the sample with the Tailored Optical Pulse
(S5)

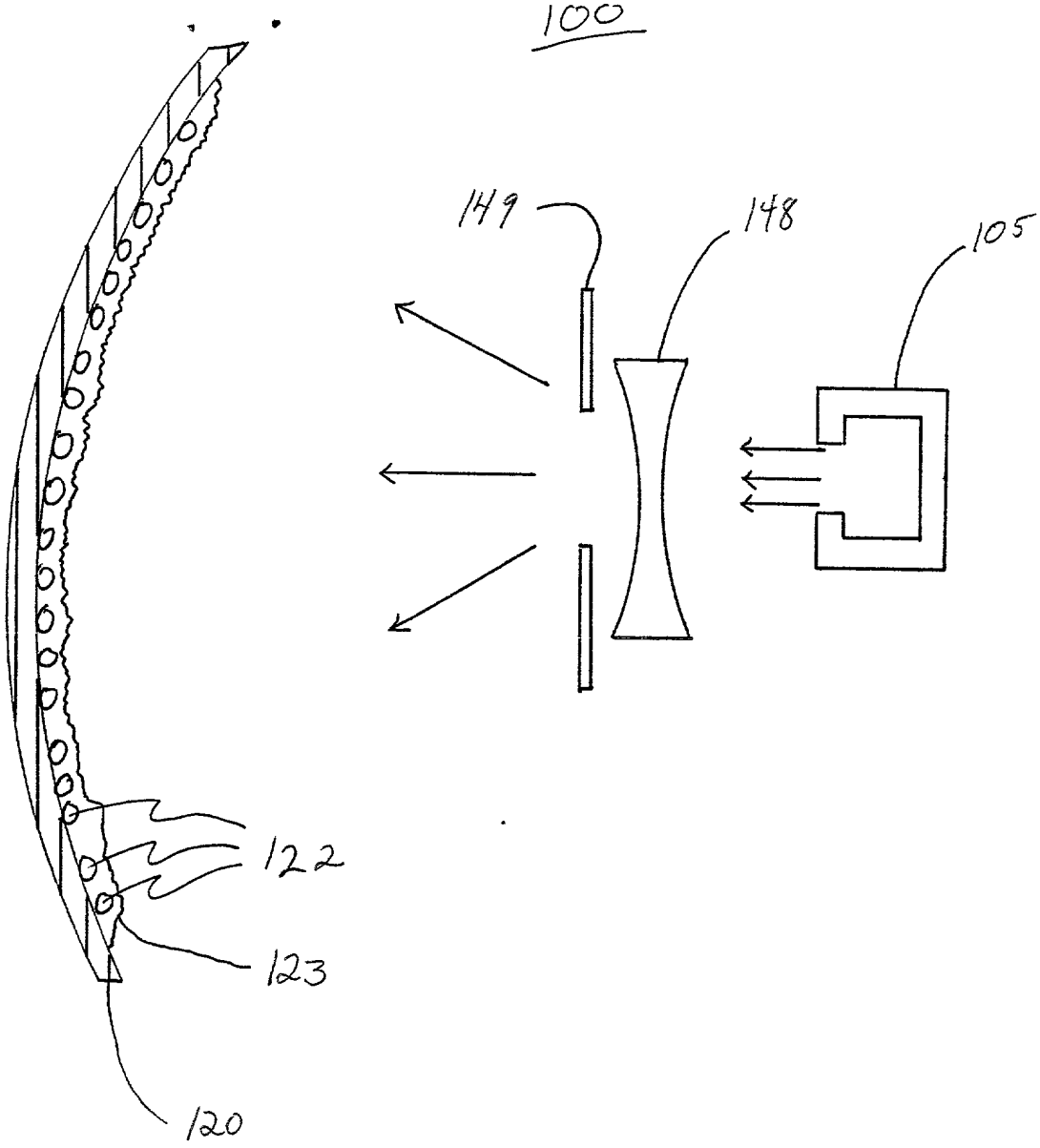


Fig. 11

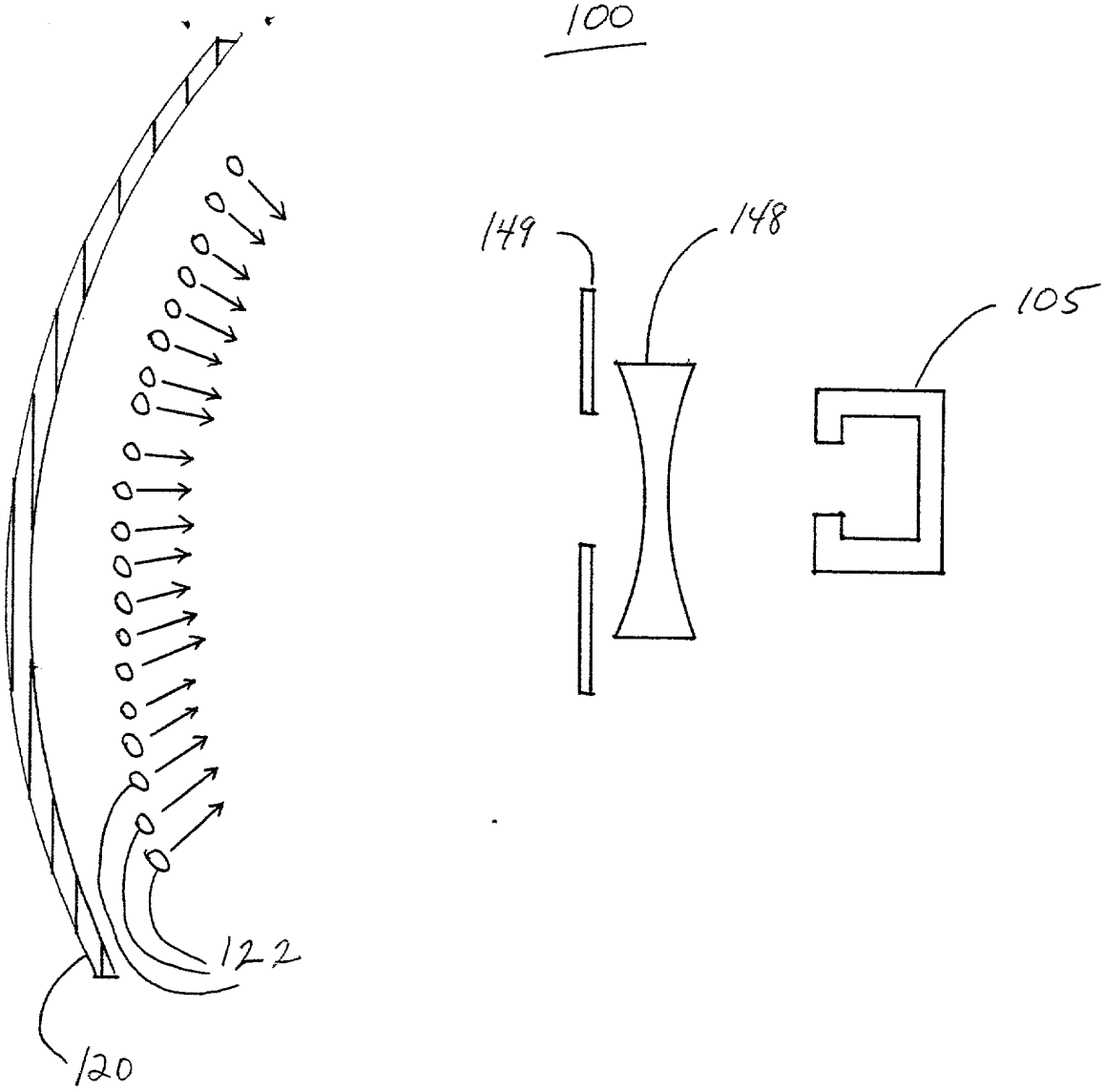


Fig 12

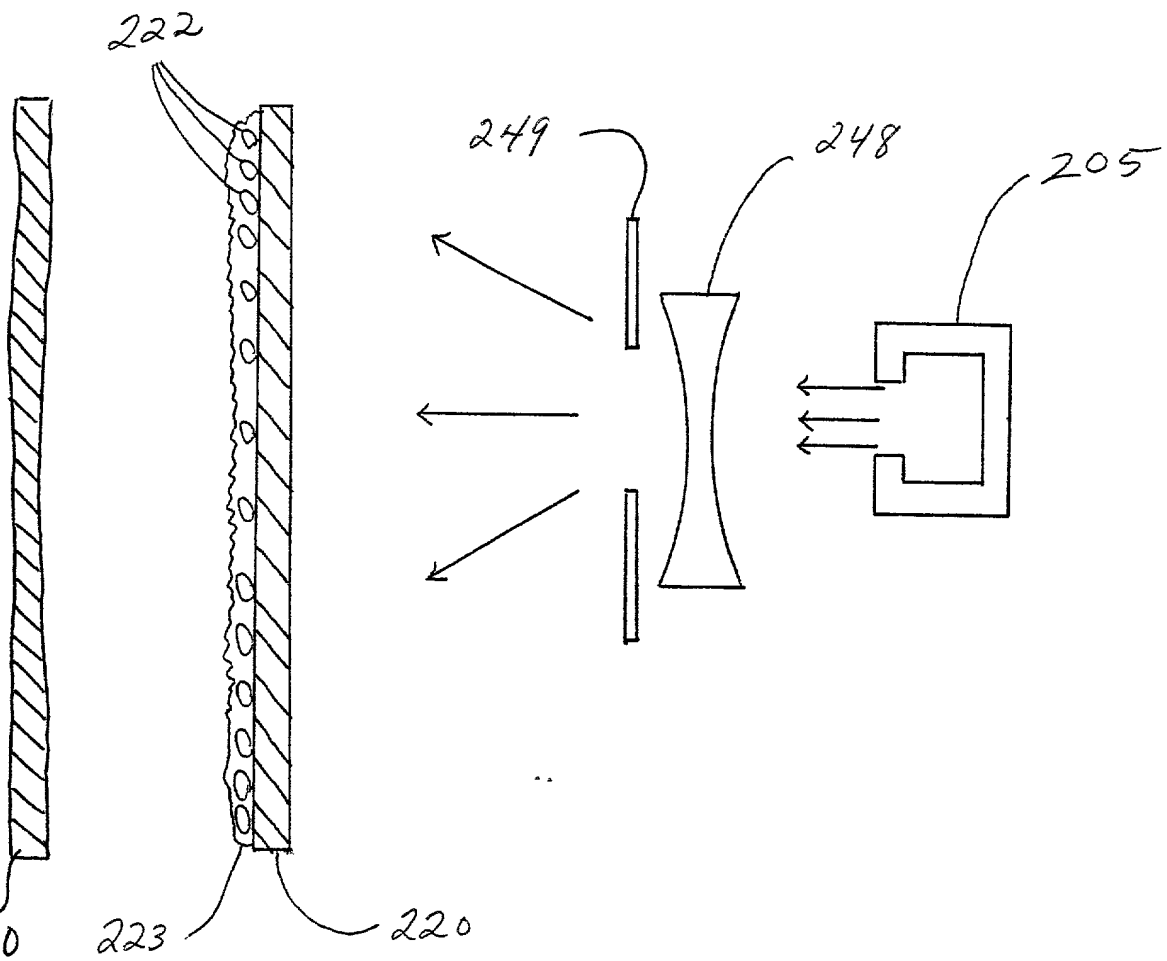


Fig 13